Cooperative National Park

RESOURCES STUDIES UNIT

Technical Report No. 29
Assessment of an Oil Spill on Selected Fishes in Rodeo Lagoon and Muir Beach

BY Johnson C.S. Wang and Thomas P. Keegan

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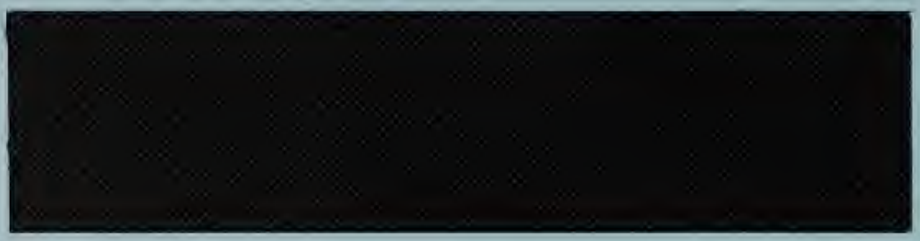
COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

University of California - National Park Service

The National Park Service and the University of California signed a Master Memorandum of Understanding on May 4, 1979, that provided for the establishment and operation of the Cooperative National Park Resources Studies Unit as an affiliate of the Institute of Ecology on the Davis Campus. Effective October 1, 1981, the Master Memorandum of Understanding was superceded by a Cooperative Agreement between the National Park Service and the University of California. This Unit is dedicated to development and facilitation of ecological, environmental and sociological programs of research and study in the interest of use, conservation, and management of natural areas and other components of the National Park system in California.

The Unit Leader conducts research and assists Park Service personnel in developing and coordinating research to provide information relevant to resource management decision in park areas. Cooperatively, the Unit Leader and the Unit Coordinator consider programs of research and study of mutual interest to the National Park Service and researchers in California and other interested parties, and promote and facilitate cooperative interactions between Park Service and research personnel on problems and programs of mutual interest.



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ABSTRACT

Target fish populations were assessed at Rodeo Lagoon in the Golden Gate National Recreation Area and Big Lagoon at Muir Beach, Marin County, California, between February and June, 1986, following an offshore spill of crude oil which was carried by wind and tides into both lagoons. Oil contamination in Rodeo Lagoon was greatest near the sand bar, the preferred spawning habitat of the tidewater goby. In the short term, expected numbers of tidewater goby spawners were absent from the contaminated area for approximately two to three months. During this time, limited spawning activity occurred elsewhere in the lagoon in marginal spawning habitat. At Big Lagoon, dissolved oxygen concentration was reduced in areas of obvious contamination where weathered oil stains persisted. Anadromous fish species, especially newly-emerged salmonids, were observed in the areas of contamination with little apparent impact.

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INTRODUCTION

Rodeo Lagoon is located north of San Francisco Bay between Fort Berry and Fort Cronkhite in the Golden Gate National Recreation Area (GGNRA). The lagoon, separated from the Pacific Ocean by a sand bar, receives various amounts of sea water over the sand bar during very high tides or when large waves are generated by storm events. The sand bar is also frequently breached during winter after periods of heavy rainfall. Periodically, the sand bar is artificially breached by the GGNRA if water levels in the lagoon become too high. Sand movement processes eventually result in the reformation of the sandbar. At the east end of the lagoon, a steel weir separates the lagoon from a small freshwater lake (Rodeo Lake) immediately upstream from the brackish lagoon. Freshwater input to the lake and lagoon is from Rodeo Creek, a coastal stream with a relatively small watershed. Rodeo Lagoon, Rodeo Lake, and Rodeo Creek are described in more detail in Wang (1982 and 1984).

Muir Beach is located about three miles north of Rodeo Lagoon. Behind Muir Beach, there is a narrow body of water known as Big Lagoon. Redwood Creek runs through Muir Woods in Frank Valley and drains into Big Lagoon. Big Lagoon habitat is generally freshwater during most of the year, but may become brackish during years of reduced freshwater runoff.

T/V APEX HOUSTON, an ocean-going barge owned by the G. N. P. Barge and Tank Company of St. Louis, spilled a large quantity of crude oil just north of San Francisco Bay in early February 1986. This accident posed an immediate threat to both marine and aquatic species since the oil was flushed onto the beach and into both Rodeo and Big Lagoons through then-opened sand bars.

Rodeo Lagoon is known as one of only three locations in Marin County where remnant populations of the tidewater goby, a state-listed sensitive fish species endemic to California estuaries, are present

(Wang 1982, 1984). Steelhead and coho salmon currently use Redwood Creek and Big Lagoon as coastal spawning and nursery grounds (Gillespie and Paulsen 1977, Arnold 1971, Anderson and Paulsen 1979, May 1954, Paulsen and Reineck 1978, Scoppettone 1976). These salmonids are among the most important fishery resources of the West Coast. Further, the cumulative effect of the various small coastal streams and estuaries on total salmonid production, though undoubtedly very important, is largely undetermined.

Sampling conducted by California Department of Fish and Game (CDFG) in Redwood Creek during August, 1979, revealed the presence of three age groups of steelhead juveniles (Paulsen and Anderson 1979). The absence of coho salmon juveniles at that time may indicate the lack of summertime rearing habitat during that particular year (Smith 1986); a percentage of coho salmon juveniles are known to remain in freshwater for a year before entering the ocean habitat. Warm water temperatures which lead to faster growth may also induce coho salmon juveniles to emigrate from the freshwater rearing habitat earlier than usual (Smith 1986). However, sampling in other years indicated the presence of rearing coho salmon in Redwood Creek. Numerous coho salmon juveniles were observed throughout the length of Redwood Creek in Muir Woods during September, 1954 (May 1954). The upper reaches of Redwood Creek contained juvenile steelhead and coho salmon in July, 1977. The lower section was found to be intermittent (Gillespie and Paulsen 1977); pools appeared stagnant and no fish life was observed.

The above description indicates a general knowledge of salmonid utilization in the upper portion of Redwood Creek (i.e. above Big Lagoon). However, little information is available regarding the importance +of Big Lagoon as a rearing area for juvenile salmonids and other species. Due to the uncertainty of the resource and the impacts of the oil contamination on that resource, the management of the GGNRA called for an impact assessment of those areas both utilized by steelhead, coho salmon, and tidewater goby populations and affected by spilled oil. This project was supported by the GGNRA, National Park

Service, Department of the Interior, under contract PX 8140-6-0326/ 8142-6-0112.

METHODS

Sampling gear and techniques

Fish specimens were collected with three gear types;

1) An ichthyoplankton hoop net with 0.5 meter diameter mouth and 500 micron mesh was used to collect fish larvae and juveniles at the three stations in Rodeo Lagoon. The net was attached to a bridle two meters in length and was then hand-towed along an approximate 10 meter course at each station.

2) A 1.2 X 1.0 meter beach seine with 500 micron mesh was used to sample juvenile and adult tidewater goby and other fish species in Rodeo Lagoon. The catch from two hauls was combined for each of the three stations in Rodeo Lagoon. Approximately 10 meters of shoreline was seined during each haul.

3) A 1.2 X 3.1 meter beach seine with 0.3 cm mesh was used to catch juvenile salmon, steelhead, and other fish species at Muir Beach and Rodeo Lake stations. The catch from two hauls was combined for each station. Hauls varied from three to 10 meters along the shoreline, depending on the size of the station.

Surface to bottom water temperature and dissolved oxygen content was measured at each station with a Yellow Springs Instrument (YSI) Model 57 Dissolved Oxygen meter. Salinity was measured with a YSI model 33 salinity-conductivity meter. Hydrocarbon presence or absence was visually determined.

Sampling frequency and catch

Sampling was performed once in February, twice in March, three times in April, and twice in both May and June, 1986. The bulk of all fish captured by beach seine were examined and released alive at the collection site. Ichthyoplankton samples were preserved in 10 percent formalin and brought back to the laboratory for identification and analysis. Vouchered specimens are archived at National Environmental Services in Concord, California.

Sampling stations

All sampling stations are located inshore of Rodeo Beach (Figure 1) and Muir Beach (Figure 2). The four stations located at Rodeo Lagoon and Rodeo Lake were established in January 1980. They were subsequently sampled once or twice a month over a three year period (January 1980-December 1982) prior to the present study. Site descriptions are presented in more detail by Wang (1982 and 1984). Primary characteristics of each station are presented in Table 1.

Figure 1. Rodeo Lagoon and Rodeo Lake sampling stations.

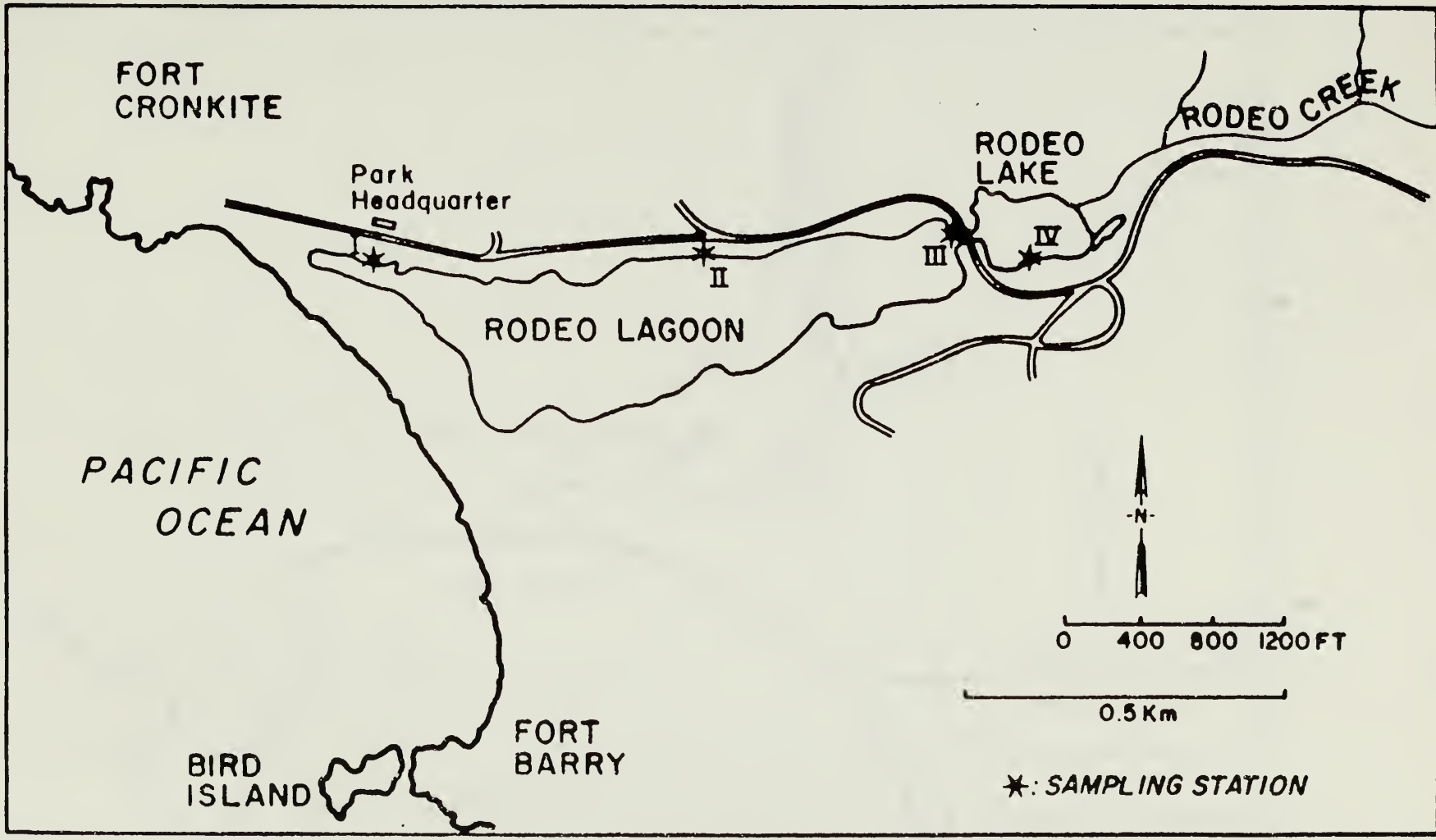

Figure 2. Muir Beach and Redwood Creek sampling stations.

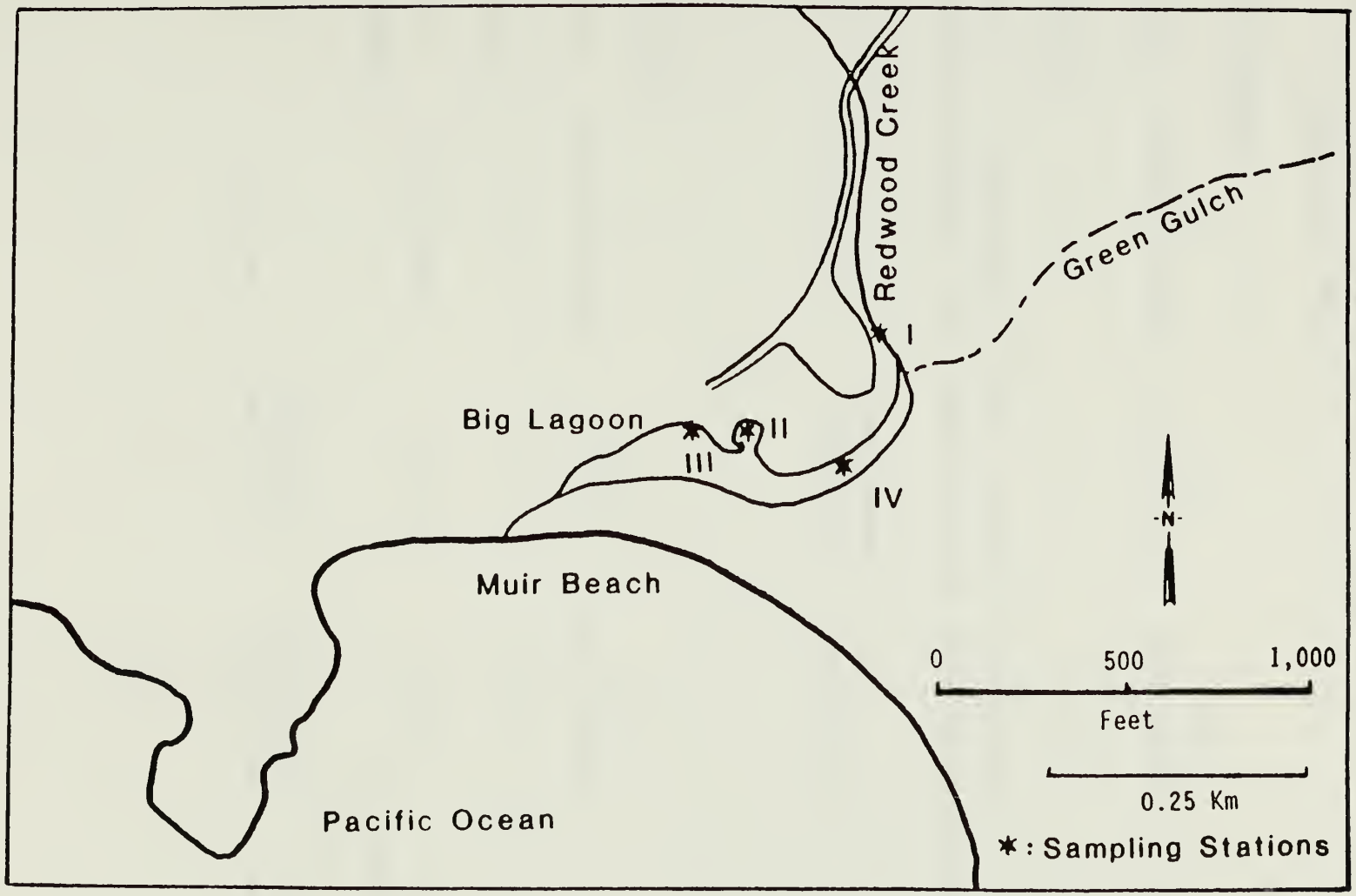

Table 1. Primary characteristics of Rodeo Lagoon and Muir Beach sampling sites.

RODEO LAGOON

Station	(I) Wooden Bridge	(II) Stop Sign	(III) Road Bridge	(IV) Rodeo Lake
Depth (m)	0-1.4	0-1.2	0-1.0	0-1.2
Bottom Substrate	sand,clay, submerged veg.	soft mud,clay, submerged veg.	mud,gravel, submerged veg.	clay,detritus submerged veg.
shore zone	Salicornia	herbaceous vegetation	Salicornia	shrubs

MUIR BEACH

Station	(I) Redwood Creek	(II) Pool	(III) Muir Beach	(IV) Lagoon
Depth (m)	0-1.4	0-1.4	0-1.4	0-1.0
Bottom Substrate	sand,gravel	sand,mud	sand	mud,gravel submerged veg.
Shore Zone	riparian	herbaceous vegetation	herbaceous vegetation	herbaceous vegetation

RESULTS AND DISCUSSION

PHYSICAL-CHEMICAL ASPECTS

All physical-chemical parameters measured during this study are presented along with the daily catch summaries in the Appendix.

During the five months of sampling (February-June) in 1986, surface water temperatures ranged from 14.0 to 20.5°C. and dissolved oxygen concentrations were measured from 6.0 to 12.0 ppm in Rodeo Lagoon. At Muir Beach sampling stations water temperatures and dissolved oxygen concentration ranged from 12.5 to 23.0°C. and from 1.0 to 12.0 ppm, respectively. Hydrocarbon presence (weathered crude oil) was noted at the 'pool' station of Muir Beach in February and March. Salinity measurements at Rodeo Lagoon ranged from 0 to 5.0 ppt while measurements taken at Muir Beach stations confirmed the absence of saline water.

Water temperatures were generally cooler at those stations proximal to an incoming freshwater source. Slightly higher water temperatures were noted near the sand bars of both estuaries away from the freshwater source.

The lowest dissolved oxygen concentration measured at Rodeo Lagoon stations was 6.0 ppm, however, most measurements were generally greater than 10 ppm. The 'pool' station at Muir Beach contained the lowest measured concentration of dissolved oxygen. During February and March when oil was present, readings as low as 1.0 ppm were noted. Dissolved oxygen content improved substantially (6.0 to 10.0 ppm) in April and June as the oil dissipated. Measurements from all other stations at Muir Beach indicated normal levels of dissolved oxygen saturation.

BIOLOGICAL ACCOUNTS

Rodeo Lagoon Fish Collection

I) Tidewater Goby, *Eucyclogobius newberryi* (Girard)

The tidewater goby was the most abundant species collected during the current study at Rodeo Lagoon. A total of 1,462 specimens which included 1,055 larvae, 381 juveniles and 26 adults were collected over ten field sampling trips (Table 2). Over half of all tidewater goby were collected from the station nearest the sand bar, station 'Wooden Bridge' (823 fish), followed by the catch at station 'stop sign' (512 fish), and station 'road bridge' (127 fish). No tidewater goby were collected from the station in Rodeo Lake (Table 3).

Goldberg (1977) reported that the tidewater goby had a synchronous ovarian cycle in southern California waters. In Rodeo Lagoon, spawning occurs almost all year round, peaking in early spring (Wang 1984). The tidewater goby prefers to spawn near the sand bar, a generally more saline environment than observed throughout the rest of the lagoon.

During breeding, adult fish of both sexes exhibit a darker hue dorsally; a pronounced yellowing occurs ventrally. Spawners move into shallow inshore waters with sand or gravel substrate. Swift (1980) described the male fish digging a vertical burrow approximately 100 to 200 mm into the substrate. The female attaches the eggs to the wall of the burrow; however, it is the male who guards the eggs until hatching. Newly-hatched yolksac larvae (or prolarvae) swim near the surface; they gradually assume benthic habits as they metamorphose into late postlarvae and early juveniles. In our study, most of the juveniles would congregate in small, shallow coves with dense vegetation. If the fish were disturbed, individuals immediately dove into burrows or vegetation.

Table 2. Combined catch of tidewater goby at Rodeo Lagoon by sample date and month, 1986.

LIFE STAGE	Feb 25	Mar 7	Mar 26	Apr 8	Apr 18	Apr 27	May 12	May 23	Jun 2	Jun 20	TOTAL
ADULT	0	0	0	0	3	1	3	8	5	6	26
JUVENILE	3	0	3	2	6	21	166	92	64	24	381
LARVAE	0	0	6	15	82	38	349	437	106	22	1055
TOTAL	3	9			168		1055		227		
GRAND TOTAL					1462						

Table 3. Catch of tidewater goby at Rodeo Lagoon by station and life stage, 1986.

STATION	L/S	Feb 25	Mar 7	Mar 26	Apr 8	Apr 18	Apr 27	May 12	May 23	Jun 2	Jun 20	TOTAL
WOODEN BRIDGE	ADT	0	0	0	0	2	0	2	5	5	5	19
	JUV	0	0	0	1	0	0	125	42	12	12	192
	LAR	0	0	1	13	0	3	263	273	37	22	612
												823
STOP SIGN	ADT	0	0	0	0	0	1	1	3	0	0	5
	JUV	1	0	2	1	4	1	25	50	50	8	142
	LAR	0	0	0	2	58	4	78	159	64	0	365
												512
ROAD BRIDGE	ADT	0	0	0	0	1	0	0	0	0	1	2
	JUV	2	0	1	0	2	20	16	0	2	4	47
	LAR	0	0	5	0	24	31	8	5	5	0	78
												127
RODEO LAKE	ADT	0	0	0	0	0	0	0	0	0	0	0
	JUV	0	0	0	0	0	0	0	0	0	0	0
	LAR	0	0	0	0	0	0	0	0	0	0	0
												0

As a result of the oil spill, weathered crude oil was washed into Rodeo Lagoon through a breach in the sand bar. Oil was washed at least as far into the lagoon as the east side of the wooden bridge which crosses the neck of the lagoon near the GGNRA Interpretive Center. A cleanup was immediately begun. Fortunately, heavy rains ensued shortly after the spill, helping to wash the oil out of the lagoon. By the time the first set of samples were collected in late February, the oil had all but disappeared, leaving faint yellowish stains in vegetation. No oil was visually apparent in the lagoon.

No tidewater goby were apparent in the area around the sand bar at the time of the first sampling trip in late February. Tidewater goby were absent from the 'Wooden Bridge' station near the sand bar until late March when a single larvae was collected from an ichthyoplankton sample. Normally, tidewater goby can be expected to spawn at that location in February (Wang 1982 and 1984). Very low numbers of tidewater goby larvae were observed from that station until mid-May when nearly 400 larvae and juveniles were collected. A total of 710 tidewater goby larvae, juveniles, and adults were collected in the month of May during two sampling trips. Tidewater goby larvae numbers declined in June, signaling the cessation of spawning.

During the period of low abundance between February and April at the generally most favored spawning location, the 'wooden bridge' station, higher numbers of tidewater goby were observed at the 'stop sign' and 'road bridge' stations; both of these stations were far removed from the area of oil contamination. Apparently, either the water quality or the condition of the bottom substrate was not conducive to tidewater goby spawning or rearing for a period of about two to three months. Fortunately, oil contamination was restricted to a relatively small portion of the lagoon; conditions were at least marginal at other locations within the lagoon for a limited spawn from February through April. All specimens collected were in normal condition.

II). Other Fish Species

1). Threespine stickleback, Gasterosteus aculeatus (Linnaeus)

A total of 342 threespine stickleback in various life stages were observed during the present study. Threespine stickleback was the most abundant species collected during a 1984 field study of Rodeo Lagoon (Wang 1984). The abundance ranking of this species declined; second in overall abundance during the current study presumably due to the existence of marginal spawning temperatures and the substantial increase of tidewater goby abundance during May and June. All fish collected were in normal condition.

2). Prickly sculpin, Cottus asper (Richardson)

A total of 305 specimens were collected, ranging from larvae to adults. They were more abundant during the present study than were observed during the 1984 study (Wang 1984), particularly at the 'Wooden bridge' station. The prickly sculpin prefers primarily a freshwater to low salinity habitat. The presence of larger numbers of prickly sculpin larvae at the 'wooden bridge' station, a normally saline habitat, is indicative of the low salinities observed in Rodeo Lagoon this season. All fish appeared to be normal.

3). Golden shiner, Notemigonus chrysoleucas (Mitchell)

A total of 117 juvenile golden shiner were captured at stations 'Rodeo Lake' and 'Road bridge' in May and June. Specimens collected from the 'Road bridge' station were washed downstream from the strictly freshwater habitat found in Rodeo Lake. All fish observed were normal.

4). Yellowfin goby, Acanthogobius flavimanus (Temminck and Schlegel)

The yellowfin goby is an exotic, euryhaline species common to brackish waters throughout the San Francisco Bay area. Yellowfin goby populations have flourished since accidental introduction from the Western Pacific Ocean in the early 1960's (Moyle 1976).

Nine larvae of the yellowfin goby were collected by ichthyoplankton sampling at the upper stations 'Stop sign' and 'Road bridge' in late March. A small number of adult yellowfin goby presumably entered Rodeo Lagoon when the sandbar was breached and were able to spawn in the slightly elevated salinities resulting from saltwater intrusion. Larger numbers of yellowfin goby larvae were collected during the previous study, mostly near the sandbar (Wang 1984). Yellowfin goby prefer higher salinities than were generally present in the lagoon during this season, presumably accounting for the low abundance of larvae. The unsuitability of spawning habitat near the sandbar due to the oil contamination may also have played a role in reducing the numbers of yellowfin goby larvae in the lagoon this season. No juvenile or adult yellowfin goby were taken.

5). Jacksmelt, Atherinopsis californiensis (Girard)

One jacksmelt egg case was found at the 'Wooden bridge' station in late February; one larvae was subsequently collected in early March. Apparently, eggs of the jacksmelt were introduced to the lagoon during high tides and hatched while in the lagoon. They probably perished, due to low salinities, soon after introduction .

Muir Beach Fish Collection

I). Steelhead, Salmo gairdneri (Richardson)
Coho salmon, Oncorhynchus kisutch (Walbaum)

A total of 560 juvenile steelhead and 196 juvenile coho salmon were collected (Table 4). Approximately fifteen specimens of each species were preserved for health examination in the laboratory. All others were released alive at the collection site.

The steelhead is an anadromous form of the rainbow trout. The coho salmon is one of five species of Pacific salmon; only the coho salmon and king salmon, Oncorhynchus tshawytscha, spawn in large numbers in California rivers. Adult steelhead and coho salmon spawn both in large rivers and small coastal streams. In Marin county, steelhead are known to spawn in Corte Madera Creek, Walker Creek, Lagunitas Creek, Olema Creek, Pine Gulch, and Redwood Creek. Coho salmon are generally observed only in Walker Creek, Lagunitas Creek, and Redwood Creek (Smith 1986, Emig 1985, Gillespie and Paulsen 1977).

In California coastal streams, steelhead spawning runs generally occur during the winter months and may extend into early spring. Coho salmon spawn earlier than steelhead; spawning runs are reported from November through January (Moyle 1976). Both of these salmonid species are well known for their strong homing capabilities.

Crude oil from the early February spill washed into Big Lagoon at Muir Beach as coho salmon were beginning to emerge from spawning gravels. Fortunately, most of the oil was soon washed out of the lagoon during the heavy rains in February. However, yellowish oil stains were still visible at stations 'Muir Beach' and 'Pool' from February through March. In addition, an oil sheen was apparent on the surface of the 'pool' station, a relatively deep pool (1.4 m) adjacent to and isolated from the lagoon during low tides.

Table 4. Combined catch of steelhead and coho salmon at Muir Beach by sample date and month, 1986.

SPECIES	Feb 25	Mar 7	Mar 26	Apr 8	Apr 18	Apr 27	May 12	May 23	Jun 2	Jun 20	TOTAL
STEELHEAD	0	0	31	4	51	61	105	173	66	69	560
COHO SALMON	22	14	26	65	22	30	4	4	5	4	196
TOTAL	22	71			233			286		144	
GRAND TOTAL					756						

Juvenile coho salmon were observed at all sampling stations during the first field trip (February 23, 1986). Among 22 specimens collected, six were inhabiting the 'Pool' station; dissolved oxygen concentrations were measured at 1.0 ppm near the bottom and 4.0 ppm at the surface. The juvenile coho salmon and approximately 20 adult threespine stickleback residing in the 'Pool' were apparently in good condition. Subsequent sampling at the pool revealed at least one coho salmon and several threespine stickleback with fungal infections.

Juvenile steelhead first appeared at station 'Redwood Creek' in late March, some of which still possessed a yolksac indicating recent emergence from the spawning gravels. Field observation and laboratory examination revealed that all steelhead were normal in appearance. Small steelhead juveniles (<30 mm) were captured as late as the end of May, indicating that spawning had occurred into early spring, a result of the heavier than usual rainfall. Although fish length measurements were not taken in the field, it was apparent that larger steelhead and coho salmon juveniles were present at the two stations located in the lower estuary.

The Redwood Creek/Big Lagoon system is somewhat similar to the Rodeo Creek/Rodeo Lagoon system, however Redwood Creek exhibits more freshwater runoff, spawning gravels and freshwater rearing habitat suitable for successful salmonid production.

Recent studies have indicated that long-term exposure to crude oil in the local environment may inhibit the homing instinct of salmonids during spawning escapement (Brannan et al. 1986). Overall, either steelhead or coho salmon juveniles were abundant during the time frame of this study, as determined by the relatively large catches at all stations in Muir Beach. Apparently, concentrations of spilled oil in the environment were not large enough to inhibit or mask the homing instinct of adult salmonids. This may corroborate the findings of a study by Nakatani (Nakatani et al. 1985); neither whole nor dispersed crude oil in seawater affected coho salmon homing instinct.

II). Other Fish Species

1). Threespine stickleback

A total of 575 threespine stickleback were taken from the Muir Beach sampling sites, the majority of which were collected from the 'Pool' station. Some mortalities were observed at this station in June, likely attributable to the ageing of adult spawners, particularly the male fish. Fungal infection was also apparent in some specimens. All other fish appeared normal.

2). Prickly sculpin

A total of 52 individuals, mostly adults, were taken from all stations except the 'Pool'. Three species of sculpin have been reported from Redwood Creek: prickly sculpin, riffle sculpin, and Pacific staghorn sculpin. The prickly sculpin has been observed during a past study to be relatively restricted to the lower portion of Redwood Creek; the riffle sculpin was reported higher in the drainage (Arnold 1971). The Pacific staghorn sculpin can be expected to occur only in the lower tidal area, though none were collected during this study. All sculpins collected during this study appeared normal.

3). Striped bass

One juvenile striped bass, ca. 120 mm in length, was found at station 'Muir Beach' on June 2, 1986. Apparently, this individual fish entered the estuary through the open sand bar which is located at the north end of the beach. This single specimen was in normal condition. Striped bass have been collected from Big Lagoon in the past (Arnold 1971). It has been suggested that young striped bass may congregate in such small coastal estuaries for feeding, possibly on young of the year salmonids during emigration (Arnold 1971).

CONCLUSION

The tidewater goby is a small, sensitive native fish endemic to California coastal lagoons; it also has a short life cycle. The survival of this species depends on the presence of protective natural water bodies such as Rodeo Lagoon, with no development or long-term disturbances to the environment. During the introduction of spilled oil into Rodeo Lagoon in February, 1986, a relatively short-term environmental disturbance, the tidewater goby was apparently able to avoid the contaminated area. After a two to three month period, the contaminated area was once again habitable, as determined by the increase in numbers of the tidewater goby near its historically preferred area around the sandbar.

Two factors were instrumental in limiting the severity of the oil spill on the tidewater goby resource; immediate cleanup and heavy rainfall soon after the oil spill incident. The heavy rains were favorable to the tidewater goby in at least three respects: 1) the tidewater goby prefers relatively low salinities (<5ppm); 2) the lower salinities resulted in less than favorable conditions for the yellowfin goby, an introduced species that competes with the tidewater goby for space and food; and 3) most of the oil remaining in the lagoon after cleanup operations was washed out through the breached sand bar. Had the oil spill been more serious or had the heavy rainfall not occurred immediately after the spill, the impacts on the tidewater goby could have been far more serious. In short, if the environmental disturbance (i.e. oil spill) had taken place over a longer time period, or if the protective water body had been too small, the survival of the entire tidewater goby population could have been jeopardized. The negative effects of this oil spill were far outweighed by the positive effects of extremely favorable environmental conditions (i.e. heavy rainfall and lowered salinities) for the tidewater goby.

Both steelhead and coho salmon are important fishery resources to the California commercial and sport fisherman. The ecological requirements for succesful salmonid production are highly restricted and largely depend upon adequate volume and quality of waters where spawning and rearing occur. The introduction of oil contamination into such waters may result in the local depletion of dissolved oxygen. In addition, many hydrocarbon constituents in crude oil ellicit toxicologic hazards to fish.

Oil contamination from this oil spill incident did not occur in salmonid spawning grounds or upstream rearing areas in Redwood Creek. Thus, both steelhead and coho salmon fry were able to rear in clean waters immediately after hatching and emergence from the spawning gravels. Young-of-the-year coho salmon and steelhead remain in freshwater for varying amounts of time prior to emigration to the estuary where additional rearing takes place. Fortunately, the heavy rains washed most of the oil contamination from the downstream, estuarine rearing area before its utilization by the majority of coho salmon smolts. No steelhead young were in the area during the time of the spill. Therefore, impacts to both the coho salmon and steelhead fisheries appear to be negligible. No baseline information on the utilization of the estuary by resident species prior to the oil spill is available. However, the fish species assemblage, abundance and health in Big Lagoon indicate that overall impacts to the estuary were minimal.

Management recommendations for the protection of the tidewater goby in Rodeo Lagoon have been addressed and presented to GGNRA in previous reports (Wang 1982 and 1984). Some of those recommendations are reproduced here. It should be noted that the recommendation to regulate the lagoon salinity to as low as 0-5 ppt as occurred naturally this season accurately predicted relative tidewater goby abundance in Rodeo Lagoon in relation to the lagoon's salinity as well as abundance of competing species. Low salinities (<5 ppt) provide optimum spawning and rearing habitat for the tidewater goby. Low salinities are detrimental, however, to reproductive activity and

rearing of yellowfin goby, Pacific staghorn sculpin, jacksmelt, and other species which may compete with or prey upon the tidewater goby. General management recommendations for Muir Beach are also included.

MANAGEMENT RECOMMENDATIONS

1. The control of salinity in Rodeo Lagoon at just below 5 ppt will minimize yellowfin goby and other exotic species populations in the lagoon, resuting in improved conditions for the tidewater goby population. Therefore, inflow of seawater through the breached sandbar should be discouraged. In winter, the sandbar is either naturally or artificially breached by the National Park Service (NPS) during periods of heavy rainfall. As the volume of freshwater runoff subsides, saltwater intrusion into the lagoon occurs. The sandbar eventually reforms due to the natural processes of sand movement. The NPS should monitor the salinity of the lagoon after the subsidence of freshwater runoff. If salinities approach 4 ppt, the NPS should hasten the process of sandbar reclosure.

2. The lagoon and adjacent areas have received tremendous visitor interest in recent years. A long-term monitoring program for the tidewater goby in the lagoon should be established. This will permit better understanding of the ecological status of this native fish and provide more information on its ecological requirements. The tidewater goby in Rodeo Lagoon may serve as a good indicator species both for monitoring the health of the lagoon and for providing public awareness.

3. Since both Rodeo and Big Lagoons are small bodies of water and are enclosed most of the year, the National Park Service can improve water quality by eliminating the discharge of waste from National Park Service facilities into Rodeo Lagoon and should take steps to minimize litter into both lagoons.

4. Should a future oil spill occur offshore of San francisco Bay, all steps should be immediately taken to prevent the introduction of oil into either lagoon. Upon the introduction of oil into either lagoon, cleanup operations should immediately commence, especially near the sandbar in Rodeo Lagoon.

5. Instream or streamside development of Redwood and Rodeo Creek should be strongly discouraged. Water should not be diverted or pumped from Redwood Creek, especially during the spring and summer months when rearing coho salmon and steelhead juveniles are present.

6. The introduction of nutrients into Redwood Creek from agricultural practices or horse stables should be prevented. Eutrophic conditions are present in the upper lagoon near the confluence with Green Gulch as a result of present nutrient loading.

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LITERATURE CITED

Anderson, K.R. and I.L. Paulsen. 1979. Redwood Creek, Marin County; fish population sampling, August 15, 1979. Unpub. Memo, Calif. Dep't. of Fish and Game, Central Fish. Dist., Region 3.

Arnold, J.R. 1971. A study of the silver salmon Oncorhynchus kisutch (Walbaum) and steelhead rainbow trout Salmo gairdneri gairdneri (Richardson) in Redwood Creek, Marin County, California. U.S. Department of Interior, National Park Service, Contract no. 14-10-9-990-33.

Brannon, E.L., T.P. Quinn, and C.D. McAuliffe. 1986. The homing of adult chinook salmon after brief exposure to whole and dispersed crude oil. Trans. Amer. Fish. Soc. (in press).

Emig, J.W. 1985. Fish population survey, Lagunitas Creek drainage, Marin County, 1982. Calif. Dep't of Fish and Game, Anadromous Fisheries Branch, Admin. Report No. 85-05.

Gillespie, M. and I.L Paulsen. 1977. Fish population, Redwood Creek, Marin County. Unpub. Memo, Calif. Dep't. of Fish and Game, Central Fish. Dist., Region 3.

Goldberg, S.R. 1977. Seasonal ovarian cycle of the tidewater goby, Eucyclogobius newberryi (Gobiidae). Southwest. Nat. 22(4) : 557-559.

May, K. 1954. A biological survey of Redwood Creek, Muir Woods National Monument, Mill Valley, California. Unpub. Manuscript. U. S. National Park Service.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley, CA. 405 pp.

Nakatani, R.E., E.O. Salo, A.E. Nevissi, R.P. Whitman, B.P. Snyder, and S.P. Kaluzny. 1985. Effect of Prudhoe Bay crude oil on the homing of coho salmon in marine waters. Health and Envir. Sciences Dept. Publ. 4411. Am. Petroleum Inst., Wash. D. C.

Paulsen, I.L. and R.C. Reineck, Jr. 1978. Silver salmon and steelhead survey of Redwood Creek, Marin County. Unpub. Memo, Calif. Dep't of Fish and Game, Central Fish. Dist., Region 3.

Scopettone, G. 1976. The status of steelhead and silver salmon spawning success in Redwood, Pine Gulch, Lagunitas, and Corte Madera Creeks, Marin County; Mid-February, 1976. Unpub. Memo, Calif. Dep't. of Fish and Game, Central Fish. Dist., Region 3.

Smith, G.E. 1986. Instream flow requirements, anadromous salmonids spawning and rearing, Lagunitas Creek, Marin County. Stream Evaluation Report No. 86-2, April 1986. California Department of Rish and Game, Stream Evaluation Program.

Swift, C.C. 1980. Eucyclogobius newberryi (Girard), tidewater goby. In: Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History. 854 pp.

Wang, J.C.S. 1982. Early life history and protection of the tidewater goby, Eucyclogobius newberryi, in the Rodeo Lagoon of the Golden Gate National Recreation Area. Cooperative National Park Resources Study Unit and University of California, Davis. Tech. Rep. No. 7, 24 pp.

Wang, J.C.S. 1984. On the ecological status of the tidewater goby, Eucyclogobius newberryi (Girard), in a lagoon and lake of the Golden Gate National Recreation Area, CA. Cooperative National Park Resources Study Unit and University of California, Davis. Tech. Rep. No. 15, 25 pp.

DATA COLLECTED AT RODEO LAGOON, FEBRUARY 25, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	16.5-17.0	16.5	17.0	16.5
DISSOLVED OXYGEN (ppm)	8.0-8.5	7.5-9.5	8.0-9.0	8.0-9.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<2	0	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	0	0	0	0
JUVENILE	0	1	2	0
LARVAE	0	0	0	0
OTHERS:	THREESPINE STICKLEBACK JUVENILE-1 JACKSMELT EGGCASE	THREESPINE STICKLEBACK JUVENILE-1	THREESPINE STICKLEBACK JUV/ADULT-5 PRICKLY SCULPIN LARVAE-1	THREESPINE STICKLEBACK ADULT-1 PRICKLY SCULPIN ADULT-1

DATA COLLECTED AT RODEO LAGOON, MARCH 7, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	14.8	15.2	14.8	14.0
DISSOLVED OXYGEN (ppm)	11.0	11.0	9.0	10.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<2	<2	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	0	0	0	0
JUVENILE	0	0	0	0
LARVAE	0	0	0	0
OTHERS:	THREESPINE STICKLEBACK ADULT-1 JACKSMELT LARVAE-1	THREESPINE STICKLEBACK ADULT-2	THREESPINE STICKLEBACK ADULT-5	0

DATA COLLECTED AT RODEO LAGOON, MARCH 26, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	16.0	16.0	15.3	14.0
DISSOLVED OXYGEN (ppm)	10.5	10.5-11.0	10.5	10.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<2	<2	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	0	0	0	0
JUVENILE	0	2	1	0
LARVAE	1	0	5	0
OTHERS:	THREESPINE STICKLEBACK ADULT-6	THREESPINE STICKLEBACK JUV/ADULT-13	THREESPINE STICKLEBACK JUV/ADULT-4	0
	PRICKLY SCULPIN LARVAE-3 ADULT-1	YELLOWFIN GOBY LARVAE-1	YELLOWFIN GOBY LARVAE-8	

DATA COLLECTED AT RODEO LAGOON, APRIL 8, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	15.5	15.5	16.0	16.5
DISSOLVED OXYGEN (ppm)	10.0	10.0	10.0	6.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<2	<2	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	0	0	0	0
JUVENILE	1	1	0	0
LARVAE	13	2	0	0
OTHERS:	THREESPINE STICKLEBACK ADULT-1 PRICKLY SCULPIN LARVAE-1	THREESPINE STICKLEBACK LARVAE-1 ADULT-1	PRICKLY SCULPIN LARVAE-1	0

DATA COLLECTED AT RODEO LAGOON, APRIL 18, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	15.0	15.5	15.8	14.5
DISSOLVED OXYGEN (ppm)	10.0	10.0	10.2	9.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<3	<3	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	2	0	1	0
JUVENILE	0	4	2	0
LARVAE	0	58	24	0
OTHERS:	THREESPINE STICKLEBACK ADULT-1 PRICKLY SCULPIN LARVAE-2 JUVENILE-1	THREESPINE STICKLEBACK JUVENILE-25	THREESPINE STICKLEBACK ADULT-3 PRICKLY SCULPIN LARVAE-1	THREESPINE STICKLEBACK ADULT-1

DATA COLLECTED AT RODEO LAGOON, APRIL 27, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	16.5	16.5	17.5	15.8
DISSOLVED OXYGEN (ppm)	10.0	10.5	10.0	9.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<5	<5	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	0	1	0	0
JUVENILE	0	1	20	0
LARVAE	3	4	31	0
OTHERS:	THREESPINE STICKLEBACK JUVENILE-1 ADULT-5	THREESPINE STICKLEBACK JUVENILE-33 ADULT-3	THREESPINE STICKLEBACK JUVENILE-3 ADULT-2	THREESPINE STICKLEBACK JUVENILE-3
				PRICKLY SCULPIN ADULT-1

DATA COLLECTED AT RODEO LAGOON, MAY 12, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	17.5	18.0	17.5	18.0
DISSOLVED OXYGEN (ppm)	9.0	11.0	9.5	8.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<4	<4	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	2	1	0	0
JUVENILE	125	25	16	0
LARVAE	263	78	8	0
OTHERS:	THREESPINE STICKLEBACK JUVENILE-20 ADULT-15	THREESPINE STICKLEBACK JUVENILE-10 ADULT-5	THREESPINE STICKLEBACK ADULT-5	THREESPINE STICKLEBACK JUVENILE-2
	PRICKLY SCULPIN JUVENILE-33	PRICKLY SCULPIN LARVAE-1 JUVENILE-10	PRICKLY SCULPIN JUVENILE-3	GOLDEN SHINER JUVENILE-35

DATA COLLECTED AT RODEO LAGOON, MAY 23, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	16.5	17.5	16.5	16.5
DISSOLVED OXYGEN (ppm)	10.0	12.5	10.5	9.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<5	<5	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	5	3	0	0
JUVENILE	42	50	0	0
LARVAE	273	159	5	0
OTHERS:	THREESPINE STICKLEBACK ADULT-15	THREESPINE STICKLEBACK LARVAE-1 JUVENILE-6	THREESPINE STICKLEBACK ADULT-1	THREESPINE STICKLEBACK JUVENILE-5
	PRICKLY SCULPIN JUVENILE-20	PRICKLY SCULPIN JUVENILE-10	PRICKLY SCULPIN JUVENILE-5	GOLDEN SHINER JUVENILE-30

DATA COLLECTED AT RODEO LAGOON, JUNE 2, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	16.0	17.0	16.5	15.0
DISSOLVED OXYGEN (ppm)	10.0	11.5	9.5	9.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	<5	<5	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	5	0	0	0
JUVENILE	12	50	2	0
LARVAE	37	64	5	0
OTHERS:	THREESPINE STICKLEBACK JUVENILE-30	THREESPINE STICKLEBACK JUVENILE-33	THREESPINE STICKLEBACK JUVENILE-5	THREESPINE STICKLEBACK LARV/JUV-10 ADULT-2
	PRICKLY SCULPIN JUVENILE-50	PRICKLY SCULPIN JUVENILE-5	PRICKLY SCULPIN JUVENILE-2	

DATA COLLECTED AT RODEO LAGOON, JUNE 20, 1986.

STATION	WOODEN BRIDGE	STOP SIGN	ROAD BRIDGE	RODEO LAKE
WATER TEMPERATURE	20.5	20.5	19.0	19.5
DISSOLVED OXYGEN (ppm)	9.0	12.0	10.0	8.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	4.5	4.5	0	0
CATCH				
TIDEWATER GOBY:				
ADULT	5	0	1	0
JUVENILE	12	8	4	0
LARVAE	22	0	0	0
OTHERS:	THREESPINE STICKLEBACK LARVAE-3 JUVENILE-10 PRICKLY SCULPIN JUVENILE-150	THREESPINE STICKLEBACK JUVENILE-39	THREESPINE STICKLEBACK JUVENILE-3 PRICKLY SCULPIN JUVENILE-4 GOLDEN SHINER JUVENILE-2	GOLDEN SHINER LARV/JUV-50

DATA COLLECTED AT MUIR BEACH, FEBRUARY 25, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	14.0	14.0	19.0	14.0
DISSOLVED OXYGEN (ppm)	10.4	1.0-4.0	8.0-9.0	10.5
HYDROCARBON PRESENCE	NO	YES	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	0	0	0	0
COHO SALMON	9	6	6	1
OTHERS:	THREESPINE STICKLEBACK ADULT-15	THREESPINE STICKLEBACK ADULT-20	THREESPINE STICKLEBACK ADULT-15	THREESPINE STICKLEBACK ADULT-5
	PRICKLY SCULPIN ADULT-1			

DATA COLLECTED AT MUIR BEACH, MARCH 7, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	13.0	12.8-13.0	13.0	12.8-13.0
DISSOLVED OXYGEN (ppm)	10.8	7.0	11.5	11.0
HYDROCARBON PRESENCE	NO	YES	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	0	0	0	0
COHO SALMON	6	3	0	5
OTHERS:	THREESPINE STICKLEBACK ADULT-7	THREESPINE STICKLEBACK JUV/ADULT-15	0	THREESPINE STICKLEBACK ADULT-5

DATA COLLECTED AT MUIR BEACH, MARCH 26, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	13.2	15.2	18.0	14.0
DISSOLVED OXYGEN (ppm)	12.0	7.0-8.0	10.5	10.5-11.5
HYDROCARBON PRESENCE	NO	YES	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	31	0	0	0
COHO SALMON	2	2	20	2
OTHERS:	THREESPINE STICKLEBACK ADULT-15	THREESPINE STICKLEBACK ADULT-37	THREESPINE STICKLEBACK ADULT-3	THREESPINE STICKLEBACK ADULT-2

DATA COLLECTED AT MUIR BEACH, APRIL 8, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	14.0	16.5	19.5	14.5
DISSOLVED OXYGEN (ppm)	12.0	6.5	8.5	12.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	3	1	0	0
COHO SALMON	35	1	20	9
OTHERS:	THREESPINE STICKLEBACK ADULT-10	THREESPINE STICKLEBACK JUV/ADULT-100	THREESPINE STICKLEBACK ADULT-5 PRICKLY SCULPIN ADULT-3	THREESPINE STICKLEBACK ADULT-5 PRICKLY SCULPIN ADULT-2

DATA COLLECTED AT MUIR BEACH, APRIL 18, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	12.5	14.5	17.5	14.5
DISSOLVED OXYGEN (ppm)	12.0	9.5	8.5	12.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	50	0	0	1
COHO SALMON	1	1	4	16
OTHERS:	THREESPINE STICKLEBACK ADULT-1	THREESPINE STICKLEBACK ADULT-100	THREESPINE STICKLEBACK ADULT-15	THREESPINE STICKLEBACK ADULT-5
				PRICKLY SCULPIN JUVENILE-1
				ADULT-1

DATA COLLECTED AT MUIR BEACH, APRIL 27, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	13.5	17.0	21.0	15.0
DISSOLVED OXYGEN (ppm)	12.0	9.0	10.0	11.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	44	0	11	6
COHO SALMON	0	5	21	4
OTHERS:	THREESPINE STICKLEBACK ADULT-5	THREESPINE STICKLEBACK ADULT-100	THREESPINE STICKLEBACK ADULT-2	THREESPINE STICKLEBACK ADULT-15
			PRICKLY SCULPIN ADULT-2	PRICKLY SCULPIN ADULT-1

DATA COLLECTED AT MUIR BEACH, MAY 12, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	13.5	17.5	17.0	16.0
DISSOLVED OXYGEN (ppm)	11.0	8.5	10.5	12.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	35	0	25	45
COHO SALMON	1	2	1	0
OTHERS:	0	THREESPINE STICKLEBACK JUVENILE-3 ADULT-50	THREESPINE STICKLEBACK ADULT-10	THREESPINE STICKLEBACK JUV/ADULT-10
				PRICKLY SCULPIN ADULT-2

DATA COLLECTED AT MUIR BEACH, MAY 23, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	13.5	18.5	20.0	16.5
DISSOLVED OXYGEN (ppm)	11.5	9.0	10.5	11.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	150	0	16	7
COHO SALMON	0	4	0	0
OTHERS:	THREESPINE STICKLEBACK ADULT-1 PRICKLY SCULPIN ADULT-2	THREESPINE STICKLEBACK ADULT-100	PRICKLY SCULPIN ADULT-2	THREESPINE STICKLEBACK ADULT-5 PRICKLY SCULPIN ADULT-2

DATA COLLECTED AT MUIR BEACH, JUNE 2, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	14.5	20.5	21.0	18.5
DISSOLVED OXYGEN (ppm)	10.5	11.0	10.5	11.5
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	60	0	1	5
COHO SALMON	1	4	0	0
OTHERS:	0	THREESPINE STICKLEBACK JUV/ADULT-100	THREESPINE STICKLEBACK ADULT-40 STRIPED BASS JUVENILE-1	THREESPINE STICKLEBACK ADULT-10 PRICKLY SCULPIN ADULT-15

DATA COLLECTED AT MUIR BEACH, JUNE 20, 1986.

STATION	REDWOOD CREEK	POOL	MUIR BEACH	LAGOON
WATER TEMPERATURE	17.0	23.0	23.5	19.5
DISSOLVED OXYGEN (ppm)	10.5	10.0	10.0	10.0
HYDROCARBON PRESENCE	NO	NO	NO	NO
SALINITY (ppt)	0	0	0	0
CATCH				
JUV. SALMONIDS:				
STEELHEAD	50	0	4	15
COHO SALMON	1	3	0	0
OTHERS:	0	THREESPINE STICKLEBACK JUV/ADULT-150	THREESPINE STICKLEBACK JUV/ADULT-100	THREESPINE STICKLEBACK JUV/ADULT-20 PRICKLY SCULPIN JUV/ADULT-20

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On the Ecological Status of the Tidewater Goby, Eucyclogobius newberryi (Girard), in a Lagoon and Lake of the Golden Gate National Recreation Area, California. 25 pp.
Wang, J. C. S.

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Norris, L. L.

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Fellers, G. M. and B. W. Arnold

BIANNUAL and ANNUAL REPORTS

Biannual Report No. 1	November 1979	**NOT AVAILABLE**
Biannual Report No. 2	March 1980	
Biannual Report No. 3	September 1980	**NOT AVAILABLE**
Biannual Report No. 4	June 1981	
Biannual Report No. 5	December 1981	
Biannual Report No. 6	June 1982	
Biannual Report No. 7	December 1982	
Annual Report No. 8	December 1983	**NOT AVAILABLE**
Annual Report No. 9	December 1984	
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